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8 pages

Messrs
EUROPEAN PATENT OFFICE
as PCT IPEA
D-80298 MÜNCHEN
GERMANY

Attention to: Mr. Avramidis P.

Our Ref: 61.S3502WO17 RF/rc **Your ref:** **Bologna,** 23 September 2004

Re: **International Patent Application No. PCT/IB03/03207**
filed on 30 July 2003
in the name of SPAL S.r.l.

Dear Sirs,

this is in response to the Written Opinion dated 25.05.2004 pursuant to Rule 66 PCT.

AMENDMENTS

In response to the objections of the Written Opinion a new set of claims based on new amended claim 1 is proposed.

New amended claim 1 is based on a combination of original claims 1, 2, 8 and 9, the description at page 6, lines 25-29 and figures 1 and 2 for the features regarding the connecting ring 5.
Claims 2, 8 and 9 are deleted and the remaining dependent claims are correspondingly renumbered.

In amending claim 1 no new subject-matter is added.

Besides, all the expressions "sexagesimal", in parentheses in the application, are deleted at page 3, line 23; page 4, line 12; page 5, lines 24 and 28, in the claims and in the abstract, in order to avoid the problems of clarity. However, the aim of these expressions was to specify the nature of the degree as the 360th part of a circumference.

NOVELTY

New claim 1 includes the features regarding the specific inclination α of the blade 3 in respect to the axis 6 and the range of inclination $\gamma 1$, $\gamma 2$ of the profile at the root and at the end of the blade 3.

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The combination of these features is not present in none of the cited prior art.
It is therefore considered that new claim 1 is novel over the cited prior art.

INVENTIVE STEP

The provision of above mentioned features, which regards the specific inclination α of the blade 3 in respect to the axis 6 and the range of inclination $\gamma 1$, $\gamma 2$ of the profile at the root and at the end of the blade 3, contributes to a solution of the design problems of a fan impeller with the features of low noise, good noise spectrum distribution, high efficiency, dimensional compactness, good pressure, and to a solution of the difficulties of the production by plastic injection moulding in a single piece.

With regard to the latter problem, it should be noted that document D1 and D2 are made from metal sheet in a composite way, while document D3 (US-2002/021967) is produced with an integral forming method (paragraph 21), but having an undercut determined but the shroud 203 opposite hub 204, the fan according D3 does not permit an easy manufacturing by plastic injection moulding.

On the other hand the fan impeller according to the invention does not present any undercut. In particular, the ring 5 does not interfere with the blades 3 (figures 1 and 2), but the ring 5 is positioned on an outer diameter in respect to the blades so that the inner part of the mould can be extracted axially from both sides of the fan impeller.

It is therefore considered that new claim 1 is also inventive over the cited prior art.

* * * * *

For the reasons stated above, it is considered the new presented set of claims 1-8 meets the requirements of PCT Art. 33(2) and (3).

Waiting for your news, I remain

Yours faithfully,

BUGNION S.p.A.
Riccardo Fuochi
Riccardo Fuochi

Enclosures:
- pages 3, 4 and 5 of amended description;
- pages 8 and 9 of amended claims;
- page 10 of amended abstract;
- new set of claims (clean copy).

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the chord (L) is the length of the line joining the ends of the arc extending from the leading edge to the trailing edge for an aerodynamic profile of the blade section at the intersection between the blade and a plane perpendicular to the axis of rotation of the impeller;

the centre line (MC) of the blade is the line joining the midpoints of the chords L at the different radiuses;

the inclination (α) of the blade is the angle made by the centre line (MC) of the blade and the axis of the impeller;

the camber (f) is the longest perpendicular line to the chord (L), measured from the chord (L) to the profile or camber line of the blade; the position of the camber (f) relative to the chord (L) may be expressed as a percentage of the length of the chord itself.

With reference to Figures 1 and 2 of the accompanying drawings, the numeral 1 denotes in its entirety the impeller according to the invention.

The impeller 1 may consist of two or more modules 2, each of which comprises a plurality of blades 3 extending between a mounting disc 4 and at least one connecting ring 5. The blades 3 are connected to these components at an angle α relative to the axis 6 of the impeller 1. The angle α may range from 5 to 30 ~~(sexagesimal)~~ degrees and is preferably 10 degrees.

The blades 3 of two adjacent modules 2 may be inclined in the same direction or in opposite directions. Further, the blades 3 of one module 2 are preferably offset with respect to those of the adjacent module 2, that is to say, the end of one blade 3 of one module 2 is approximately half way along the space between two blades 3 of the adjacent module 2.

In one preferred embodiment, the impeller 1 is designed to be mounted in a centrifugal fan which sucks fluid in from both sides.

In another embodiment which is not illustrated, air is sucked in from only one side of the fan, whilst the blade 3 mounting disc 4 is located on the opposite side to that were air is sucked in. In the latter case, the impeller 1 may comprise two or more modules 2 placed side by side.

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The geometrical characteristics of each blade 3 are illustrated in Figures 3 to 5.

Figure 3 illustrates a blade 3 in a straightened plan view. The blade 3 is basically trapezoidal in shape but it might also be rectangular to enhance capacity compared to head.

The blade 3 comprises a straight leading edge A, inclined at an angle β relative to the axis 6 of the impeller 1, a straight trailing edge U, parallel to the axis 6 of the impeller 1, a root 7 attached to the 4 and an end 8 connected to the ring 5.

The angle β at which the leading edge 4 is inclined may range from 0 degrees, in the case of rectangular blades 3, to 40 ~~(sexagesimal)~~ degrees.

The rectangular or trapezoidal shape of the blades 3 depends on the type of performance required: rectangular blades provide improved capacity, while trapezoidal blades achieve greater head and better acoustic properties.

A preferred value for the angle β, which provides excellent performance in terms of capacity, pressure head and acoustic properties is 12.65 degrees.

The blade 3 extends for a length L, the profile of the blade 3 has a straightened length W1, measured along the centre line of the profile, at the root 7, and a straightened length W2 at the end 8.

The lengths W1, W2 of the profiles expressed as ratios of the length L are the following:

W2 between 0.3 and 0.5 of the length L, preferably 0.35;

W1 between 0.3 and 0.8 of the length L, preferably 0.70.

Figures 4 and 5 illustrate sections of the blade 3 profile at the root 7 and at the end 8, respectively.

The curvature of the centre line 9 of the profile at the root 7 is defined by the equation

$$Y=Y_0+\bar{a}_1(x-x_0)+\bar{b}_1(x-x_0)^2+\bar{c}_1(x-x_0)^3+\bar{d}_1(x-x_0)^4$$

where $\bar{a}_1=-\frac{1}{95{,}6};\quad \bar{b}_1=\frac{1}{27{,}9};\ \bar{c}_1=-\frac{1}{61500};\ \bar{d}_1=\frac{1}{32300}.$

The profile has a chord C1 of 21.488 mm, a constant

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thickness S1 of 1.1 mm and a camber f1 of 4.20306 mm between the centre line 9 and the chord C1.

The curvature of the centre line 10 of the profile at the end 8 is also defined by the equation

$$Y=Y_0+\bar{a}_1(x-x_0)+\bar{b}_1(x-x_0)^2+\bar{c}_1(x-x_0)^3+\bar{d}_1(x-x_0)^4$$

where the constants are the same as those stated above.

The profile has a chord C2 of 14.154 mm, a constant thickness S2 of 1.1 mm and a camber f2 of 1.5033 mm.

The cambers f1 and f2 are approximately half way along the respective chords C1 and C2, these positions being specified by the values lf1, lf2 in the table below.

The values of thickness S1, S2 and of camber f1, f2 of the profiles expressed in relation to the chords C1 and C2 are the following:

S1 between 5% and 8% of the chord length C1, preferably 6%;

f1 between 10% and 15% of the chord length C1, preferably 12%;

S2 between 6% and 10% of the chord length C2, preferably 8%;

f2 between 10% and 15% of the chord length C2, preferably 12%.

The chord C1 of the profile at the root 7 makes an angle $\gamma 1$ with the radius R1 measured at the leading edge A. The angle $\gamma 1$ may range from 50 to 80 ~~(sexagesimal)~~ degrees and is preferably 65.2 degrees.

The chord C2 of the profile at the end 8 makes an angle $\gamma 2$ with the radius R2 measured at the leading edge A. The angle $\gamma 2$ may range from 33 to 63 ~~(sexagesimal)~~ degrees and is preferably 48.2 degrees.

The description below refers to a preferred embodiment of an impeller according to the present invention without restricting the scope of the inventive concept. The impeller 1 illustrated in the accompanying drawings is made up of two symmetrical modules 2 with lateral suction.

Each module 2 has twenty-eight blades, which are offset with

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10/522302
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Claims

1. A centrifugal fan impeller (1) having an axis of rotation (6) and comprising one or more modules (2), each module (2) comprising a mounting disc (4), at least one connecting ring (5) and a plurality of blades (3) extending between the mounting disc (4) and the connecting ring (5), the blades (3) being connected to the disc (4) and ring (5) at an angle (α) relative to the axis (6) of the impeller (1), the impeller being characterised in that the angle (α) at which the blades (3) are inclined ~~may range from 5 to 30 (sexagesimal) degrees.~~

~~2. The impeller according to claim 1, characterised in that the angle (α) at which the blades (3) are inclined~~ is 10 ~~(sexagesimal)~~ degrees~~.~~ ,
in that the connecting ring (5) is positioned on an outer diameter in respect to the blades (3), whereby the inner part of the mould for producing the fan impeller (1) can be extracted axially from both sides of the fan impeller (1),
in that the profile of each blade (3) at the root is inclined at an angle (γ1) ranging from 50 to 80 degrees,
and in that the profile of each blade (3) at the end is inclined at an angle (γ2) ranging from 33 to 63 degrees, said angles (γ1, γ2) at the root (7) and at the end (8) of the blade (3) being defined as the angles made by the profile of the blade (3), at the root and end of the blade respectively, with respect to an impeller radius (R1, R2) passing through the leading edge (4) of the profile.

~~3~~2. The impeller according to claim 1 ~~or 2~~, characterised in that each blade (3) is substantially trapezoidal in shape when seen in a straightened plan view.

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~~4~~3. The impeller according to claim 1 ~~or 2~~, characterised in that each blade (3) is substantially rectangular in shape when seen in a straightened plan view.

~~5~~4. The impeller according to claim ~~3~~2, characterised in that each blade (3) has a straight leading edge (A) inclined at an angle (β) ranging from 0 to 40 ~~(sexagesimal)~~ degrees with respect to the axis (6) of the impeller (1).

~~6~~5. The impeller according to claim ~~3~~2, characterised in that each blade (3) has a straight trailing edge (U) parallel to the axis (6) of the impeller (1).

~~7~~6. The impeller according to claim ~~3~~2, characterised in that each blade (3) has a straight leading edge (A) inclined at an angle (β) of 12.65 ~~(sexagesimal)~~ degrees with respect to the axis (6) of the impeller (1).

~~8. The impeller according to any of the foregoing claims, characterised in that the profile of each blade (3) at the root is inclined at an angle (γ1) ranging from 50 to 80 (sexagesimal) degrees~~.

~~9. The impeller according to any of the foregoing claims, characterised in that the profile of each blade (3) at the end is inclined at an angle (γ2) ranging from 33 to 63 (sexagesimal) degrees.~~

~~10~~7. The impeller according to any of the foregoing claims, characterised in that the profile of each blade (3) at the root is inclined at an angle (γ1) of 65.2 ~~(sexagesimal)~~ degrees.

~~11~~8. The impeller according to any of the foregoing claims, characterised in that the profile of each blade (3) at the end is inclined at an angle (γ2) of 48.2 ~~(sexagesimal)~~ degrees.

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Claims

1. A centrifugal fan impeller (1) having an axis of rotation (6) and comprising one or more modules (2), each module (2) comprising a mounting disc (4), at least one connecting ring (5) and a plurality of blades (3) extending between the mounting disc (4) and the connecting ring (5), the blades (3) being connected to the disc (4) and ring (5) at an angle (α) relative to the axis (6) of the impeller (1), the impeller being characterised in that the angle (α) at which the blades (3) are inclined is 10 degrees, in that the connecting ring (5) is positioned on an outer diameter in respect to the blades (3), whereby the inner part of the mould for producing the fan impeller (1) can be extracted axially from both sides of the fan impeller (1),
in that the profile of each blade (3) at the root is inclined at an angle ($\gamma 1$) ranging from 50 to 80 degrees,
and in that the profile of each blade (3) at the end is inclined at an angle ($\gamma 2$) ranging from 33 to 63 degrees, said angles ($\gamma 1$, $\gamma 2$) at the root (7) and at the end (8) of the blade (3) being defined as the angles made by the profile of the blade (3), at the root and end of the blade respectively, with respect to an impeller radius (R1, R2) passing through the leading edge (4) of the profile.

2. The impeller according to claim 1, characterised in that each blade (3) is substantially trapezoidal in shape when seen in a straightened plan view.

3. The impeller according to claim 1, characterised in that each blade (3) is substantially rectangular in shape when seen in a straightened plan view.

4. The impeller according to claim 2, characterised in that each blade (3) has a straight leading edge (A) inclined at an angle (β) ranging from 0 to 40 degrees with respect to the axis (6) of the impeller (1).

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5. The impeller according to claim 2, characterised in that each blade (3) has a straight trailing edge (U) parallel to the axis (6) of the impeller (1).

6. The impeller according to claim 2, characterised in that each blade (3) has a straight leading edge (A) inclined at an angle (β) of 12.65 degrees with respect to the axis (6) of the impeller (1).

7. The impeller according to any of the foregoing claims, characterised in that the profile of each blade (3) at the root is inclined at an angle ($\gamma 1$) of 65.2 degrees.

8. The impeller according to any of the foregoing claims, characterised in that the profile of each blade (3) at the end is inclined at an angle ($\gamma 2$) of 48.2 degrees.

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